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Prediction of Blast Overturning of Objects

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Abstract

In many survivability studies of blast effects on Army equipment, it is necessary to know the prospect for equipment being overturned. This report documents a small project in which an analytical procedure of W. E. Baker for predicting the overturn of targets by airblast has been incorporated in a personal computer (PC) program. The procedure, calculations of test cases used to verify accuracy, and a listing of the computer program are presented.

Acknowledgment

We wish to thank Gordon K. Long of the U.S. Army Nuclear and Chemical Agency, Springfield, VA, for technically reviewing this report.

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1. Introduction

In many survivability studies of blast effects on Army equipment, it is necessary to know the prospect for equipment being overturned. Several codes exist for predicting equipment overturn, but they require extensive, perhaps unavailable, input information and substantial computer time. In addition, many times a quick and easy method for making overturn predictions is needed in broad studies, where overturn predictions constitute only a small portion of the overall consideration. In this regard, the overturning of objects in a blast environment may be treated by a simple, analytical procedure developed by Baker et al. (1977).

The Baker Procedure, as originally presented in the form of curves, is convenient only for the problem of determining if a target will overturn for a given blast overpressure and impulse. The problem of interest in recent studies is the determination of the threshold range (distance) for target overturn from the center of detonation of a charge. The solution requires choosing an overestimate of the distance, applying the Baker Procedure to verify that the target will not overturn, then slightly reducing the distance, and reapplying the procedure until a distance is found at which overturn occurs. Manually reusing the curves of the Baker Procedure would be a formidable effort. Therefore, it was necessary to write a computer program that could perform a large number of iterations rapidly and, thereby, quickly arrive at the desired result. The written program includes free-field blast models and TNT equivalency factors for various types of explosives that relieve the user of the burden of locating such information.

The present form of the computer program could be expanded for the purpose of solving different problems. Currently it is designed to easily determine the overturn threshold range given a target and charge (explosive type and weight); however, the inverse problem of finding what charge weight (explosive type given) is necessary to overturn the target at a given distance away from the center of detonation is clumsily solved. To solve the inverse problem would require rerunning the program a number of times (guessing a weight, finding if the target overturned, guessing again, etc.). An expansion of the program to automatically solve that problem and others would not be difficult, because no additional physics would be needed.

2. Baker Overturn Prediction Procedure

The Baker Procedure for predicting the overturn of "box-like" targets consists of two elements. One is the "threshold impulse required" to overturn the target and the other is the "impulse applied" to the target in a given blast environment. The criterion is that if the applied impulse exceeds the threshold impulse, then the target will overturn, otherwise it will not. The formulation for the threshold impulse is derived from classical mechanics, while that for the applied impulse is derived from shock physics. The derivation of the formulations is presented in Appendix A.

The threshold impulse (i_θ) to cause overturn can be found by the following equation:

$$i_\theta = \sqrt{\alpha\beta}\,\frac{mg^{1/2}\,b^{3/2}}{A\,h_{bl}}, \tag{1}$$

where

$$\alpha = \frac{2}{3} + \frac{h^2}{6b^2} + \frac{2h^2}{b^2}\left(\frac{h_{cg}^2}{h^2}\right) \tag{2}$$

and

$$\beta = \sqrt{1/4 + \frac{h^2}{b^2}\left(\frac{h_{cg}^2}{h^2}\right)} - \frac{h}{b}\left(\frac{h_{cg}}{h}\right). \tag{3}$$

Parameter definitions for equations 1–3 are as follows: height of the target is h, height of the center of gravity (HCG) is h_{cg} , height of the center of pressure* is h_{bl}, presented target area is A, width of target base is b, acceleration of gravity is g, and mass of the target is m.

The curves shown in Figure 1 are based on equation 1 and are used to determine the threshold impulse for overturning a target. Figure 1 presents the scaled target height as a function of the scaled

* The height of the center of pressure is assumed to be equal to one-half the height of the target.

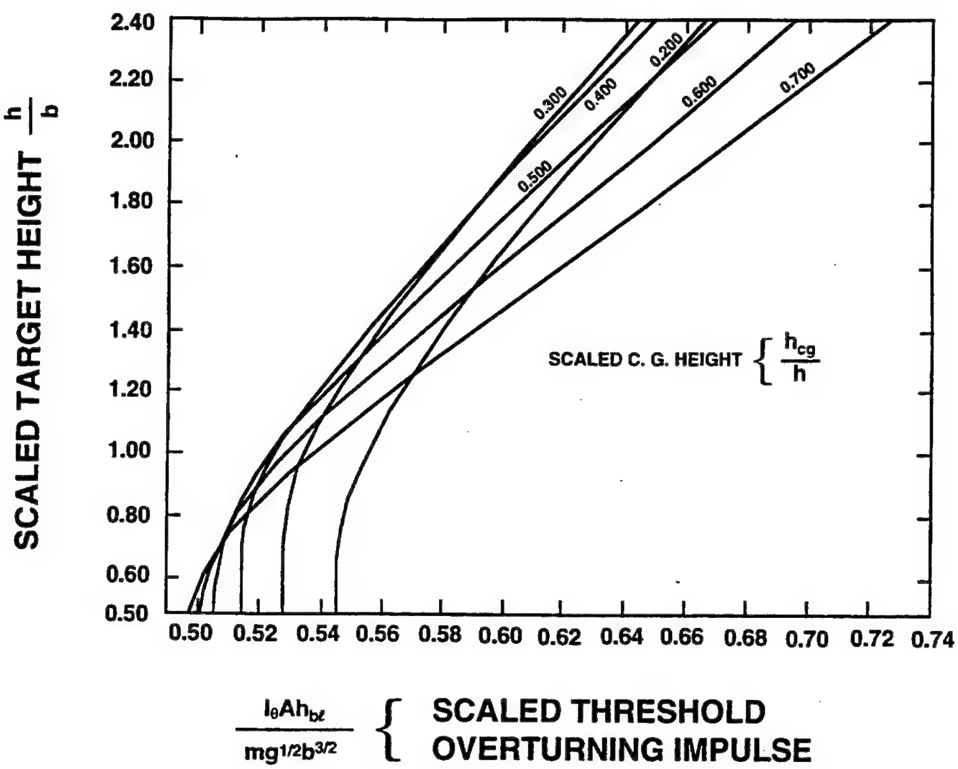


Figure 1. Threshold Impulse for Overturning a Target.

threshold overturning impulse. Each of the curves corresponds to a value of the scaled center of gravity (c.g.) height. For a specific scaled target height and a specific scaled c.g. height, a value of the scaled threshold overturning impulse can be located from which the threshold overturn impulse can be calculated by substituting values of parameters that describe the target.

The equation for determining the impulse applied to the target (i_t) is:

$$i_t = \left(\frac{\zeta}{7 + P} + \frac{\eta}{\theta} \right) \frac{p_o H}{a_o}, \tag{4}$$

where

$$P = \frac{P_S}{p_0}, \tag{5}$$

$$\zeta = 1.47\ P \left(\frac{a_0\ C_D\ i_S}{p_0\ H} \right), \tag{6}$$

$$\eta = \left(1 + \frac{3P}{7 + P}\right) P, \tag{7}$$

and

$$\theta = \sqrt{1 + 0.857 \ P}. \tag{8}$$

Parameter definitions for equations 4–8 are as follows: ambient atmospheric pressure is p_o, ambient sound velocity is a_o, free-field side-on overpressure is P_s, free-field side-on impulse is i_s, the smaller of either the target height or target width is H, and air drag coefficient is C_D.

The curves shown in Figure 2 are based on equation 4 and are used to determine the impulse imparted to a target in a specified blast environment. Figure 2 presents the scaled side-on overpressure as a function of the scaled total impulse. Each of the curves corresponds to a value of the scaled free-field impulse. For a specific scaled side-on overpressure and a specific scaled free-field impulse, a value of the scaled total impulse can be located from which the impulse applied to a target can be calculated by substituting values of parameters that relate to a target and the specific blast environment.

The derivation makes several assumptions. It is assumed the target is not initially tilted, no sliding of the target occurs, the c.g. is located at (b/2) in the horizontal direction, and the mass is uniformly distributed throughout the target. For typical trucks, buses, and other similar vehicles, the total height of the vehicle is H, but for missiles or other tall narrow objects, the diameter is H.

The (air) drag coefficient C_D varies between 1.2 for streamlined cylindrical bodies to 1.98 for long rectangular shapes as is summarized in Table 1.

Baker et al. (1977) have provided an example case to demonstrate how the curves in Figures 1 and 2 could be applied to an overturn problem. The target is a 2.5-ton Army truck located in a specific blast environment. The vehicle is assumed to have a height of 2.93 m (9.61 ft), a c.g. height of 1.37 m (4.49 ft), a track width of 1.77 m (5.81 ft), a cross-sectional area of 14.8 m^2 (159 ft^2), a

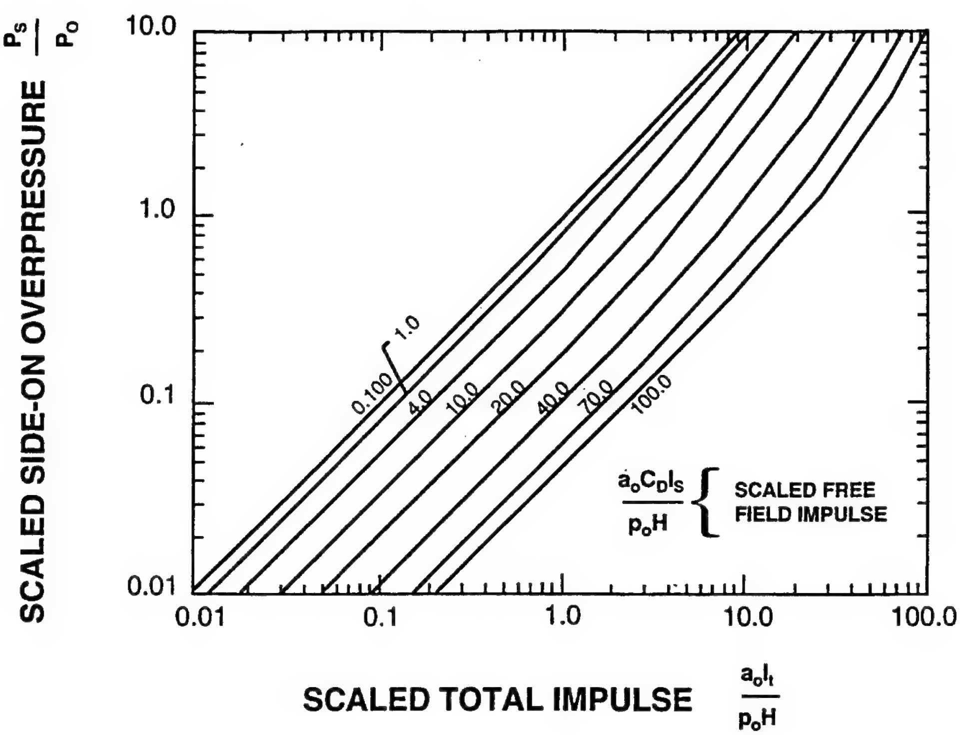


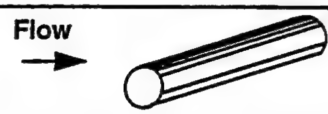
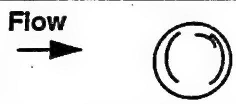
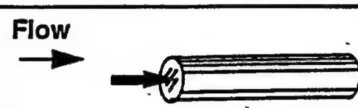
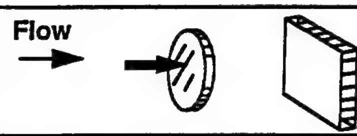
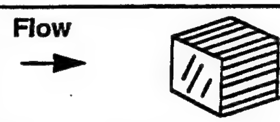
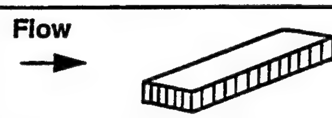
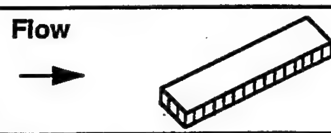
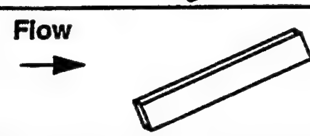
Figure 2. Impulse Imparted to a Target in a Blast Environment.

mass of 5,398 kg (1.19×10^4 lb), and a drag coefficient of 1.8. In addition, it is assumed the atmospheric pressure is 101 kPa (14.7 psi), the velocity of sound in air is 329 m/s (1,079 ft/s), the vehicle is located a distance from a detonation where the free-field pressure is 300 kPa (43.5 psi), and the free-field impulse is 1.17 kPa-s (0.17 psi-s).

Using Figure 1, the scaled target height and the scaled c.g. height are 1.65 and 0.467, respectively. For these values, the scaled threshold overturning impulse is determined to be 0.585, which leads to a threshold overturn impulse of 1.081 kPa-s (0.157 psi-s). Using Figure 2, the scaled side-on overpressure and the scaled free-field impulse are 2.96 and 2.34, respectively. With these values, it can be determined that the scaled total impulse is 3.6, which leads to an applied impulse of 3.25 kPa-s (0.471 psi-s).

Since the applied impulse (i_t) (3.25 kPa-s) is greater than the threshold impulse (i_θ) needed to overturn the target (1.08 kPa-s), it is concluded that the truck will be overturned.

Table 1. Drag Coefficients for Various Shapes (Baker et al. 1977)

SHAPE	SKETCH	C_D
Right Circular Cylinder (long rod) side - on		1.20
Sphere		0.47
Rod, end - on		0.82
Disc, face - on		1.17
Cube, face - on		1.05
Cube, edge - on		0.80
Long Rectangular Member, face - on		2.05
Long Rectangular Member, edge - on		1.55
Long Rectangular Member, face - on		1.98

3. Computerization

In our attempt to apply the Baker Procedure to problems of interest (e.g., Appendix B) it was realized that application would be easier if the procedure were computerized. Our need was an ability to quickly predict the range (distance) from the center of a detonation at which a target would overturn. Such an ability was possible using the Baker Procedure if we could perform many iterations, starting at some overestimate (in range), and quickly closing on that range at which the "threshold impulse for overturning" matched the "impulse applied" to the target. Figure 3 is a flowchart of the program to do this. For comparison, the paragraphs in this section are numbered in accordance with the numbered steps in the flowchart. The program listing is in Appendix C.

3.1 First Run on Personal Computer (PC)? The computer program (written in GW-BASIC, Version 3.2) depends partly on permanent information stored in data files that must be opened and the data used during the computations. The mechanics of the language require that permanent data be stored prior to starting computations, but this need only be done one time for each PC hard memory on which the program is to be exercised. Consequently, the setup program (OTSETUP.TEM) must be run prior to the initial run of the main program (OVERTURN.TEM) on a specific PC. Also, if the user should add other data, such as a new free-air blast model, to the setup program, then the setup program would have to be run again.

3.2 Run Setup Program. The setup program creates a number of data files for storing information, which is generated during a run, and input data, which consist of charge environmental models and TNT equivalency factors. The setup program should only be run once for a specific PC.

3.3 Choose Target. The choice of target implies that a number of target descriptions are stored in the computer and that the user is given an opportunity to choose the one desired. However, initially a list of dummy targets is displayed on the screen numbered from 1 to 30. In that case, the user is expected to choose the first dummy with the understanding that later in the calculation, an opportunity will be available to incorporate the correct target name and target characteristics. Once the correct information is provided, that target description is retained for use in the current calculation and subsequent program runs involving that target.

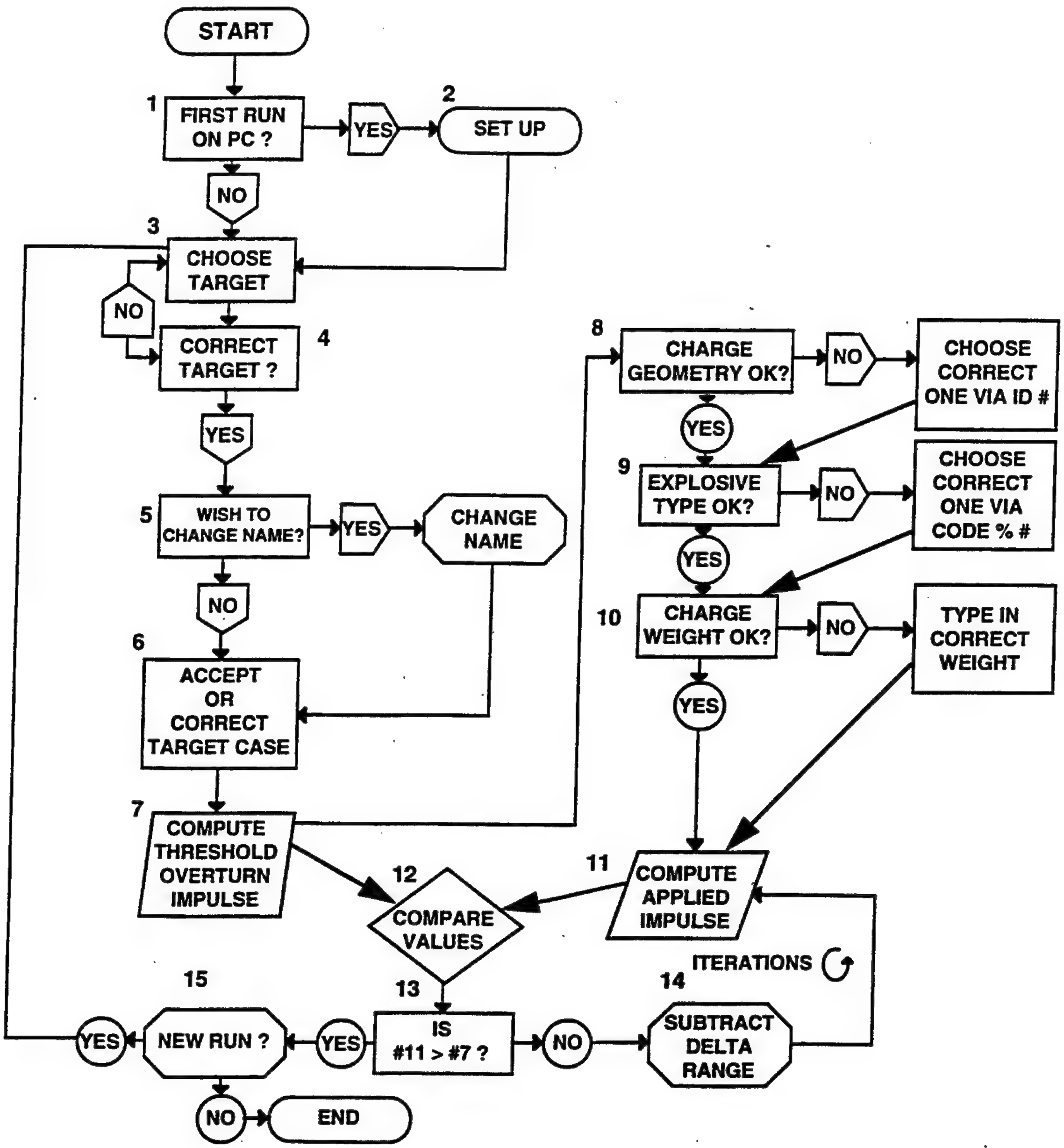


Figure 3. Flowchart of Steps Taken in Running the Overturn Program.

3.4 Correct Target? After choosing the target, the name of the target and a list of target characteristics are listed on the screen. The user is asked if the target chosen is the correct one or, in other words, the target the user intended to choose. If the answer is no, then the user is given another chance to choose the intended target. The purpose of this maneuver is to allow the user to make a correction in the event that the wrong target number was chosen. If the answer is yes, then the program moves forward to the next question.

3.5 Wish to Change Name? The next question the user is asked is if a change of name of the target is desired. If yes, an opportunity is given to change the name. Naturally, if the target in question is new, then a "dummy" has been chosen, and an insertion of the correct name is required. If the answer is no, then the program moves forward to the next question.

3.6 Accept or Correct Target Characteristics. Once the target name has been accepted or corrected, a list of the target characteristics is displayed on the screen. One by one, each characteristic is accepted or corrected by the user. The target characteristics in question are the air drag coefficient (ADC), total height of target (HH), the track width or depth of the base (DEPTH), the HCG, the presented area (AREA), which depends on the orientation of the target to the blast, and the mass of the target (M).

3.7 Compute Threshold Overturn Impulse. Currently it is always assumed that the target in question is located on the ground surface; therefore, the atmospheric parameter levels are those at sea level. The parameters are acceleration of gravity 9.75 m/s^2 (32 ft/s^2), ambient pressure 101 kPa (14.7 psi), and the ambient sound velocity 329 m/s (1,079 ft/s). These and the target characteristics just discussed are the total required input to the Baker Procedure for computing the impulse required to just overturn the target (threshold overturn impulse). The level obtained is retained for comparison purposes later in the calculation. If there is any change in a target characteristic (such as presented area due to a reorientation), the threshold overturn impulse would change.

3.8 Charge Geometry OK? The next program step is a listing of the charge characteristics on the screen. The question asked concerns the correctness of the listed charge geometry.* If the answer is yes, then the program moves forward to the next question. If the answer is no, the program provides a list on the screen of all the available charge geometries by corresponding ID numbers. The user chooses the desired charge geometry by typing the appropriate ID number and pressing Enter.

3.9 Explosive Type OK? This question asks for the type of explosive. If the correct type has been listed (answer yes), then the program moves forward to the next question. If the answer is no, then the program lists on the screen types of explosives (Baker et al. 1980) by an ID number (CODE% #) and the desired type is chosen by typing the appropriate ID number and Enter.

3.10 Charge Weight OK? This question concerns the correctness of the charge weight as listed on the screen. If the weight is OK, then the program moves on to the next major program step. If a correction is needed, the user has an opportunity to make the correction.

3.11 Compute Applied Impulse. At this point, sufficient information is available concerning the blast environment source and the target so that the applied impulse, which might overturn the target, can be ascertained for some distance (range) from the center of detonation. The initial distance, chosen "by the program," always exceeds the threshold overturn range of practical problems.

3.12 Compare Impulse Values. The value of the threshold overturn impulse is compared to the impulse applied to the target.

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* Currently there are three options in the database: a hemispherical detonation on the ground surface (Kingery and Bulmash 1984), a cylindrical detonation on the ground surface with an L/D of 3, 6, or 12 (Reisler, Giglio-tos, and Teel 1975), and a spherical free-air detonation (Kingery and Bulmash 1984), which is translated to a surface detonation by multiplying the charge weight by 1.8 (Baker et al. 1978) to account for ground reflection.

3.13 Does the Applied Impulse Exceed the Threshold Impulse? If the applied impulse does not exceed the threshold overturn impulse, the range must be reduced and step 11 is repeated. Otherwise, the current value of the range constitutes threshold range for overturn and the run is complete. If another case is to be run with some kind of change in the input, the program returns to step 3. Otherwise, the program ends.

4. Application to Field Tests

Considerable support for the Baker Procedure was obtained by comparing field test results with predictions of threshold distances for overturn. The method used was to identify the target characteristics and the charge characteristics for each test and to predict the overturn threshold distance. The input and results from these calculations are presented in Appendix B. For the predictions to be consistent with test results, the necessary conditions are: if the target overturns, the range from ground zero to the target has to be less than or equal to the prediction; if the target does not overturn, the range from ground zero to the target has to be greater than the prediction.

A total of 10 different cases from the literature (Custard and Thayer 1970; Lee and Dalton 1982) were considered in the comparison. The results are summarized in Table 2. In seven cases, the predictions are consistent with the test results; in three cases, the predictions are slightly inconsistent with the test results. A Jeep at Suffield did not overturn, though it was just inside the predicted maximum range. An M113 armored personnel carrier at SNOWBALL overturned at a range 6% greater than the predicted maximum range. An M35 truck with light shelter at DICE THROW, did not overturn, even though it was just inside the predicted maximum range. These results, while not consistent, are considered to be close. Overall, the Baker Procedure appears to be a credible method for predicting threshold ranges for overturn if reasonably correct input information is available.

Table 2. Comparison of Baker Overturn Procedure With Field Test Data

Target	Place or Event	Test Range (ft)	Overturned?	Predicted Range (ft)	Consistent?
School Bus	China Lake[a]	205	No	159	Yes
Pickup with Camper	China Lake[a]	180	No	153	Yes
Large Bus	DIAL PACK[b]	1,200	No	1,044	Yes
Small Bus	DIAL PACK[b]	3,000	No	1,294	Yes
M38A1 Jeep (7 ea.)	Suffield[c]	300, 300, 365, 365 424, 424, and 495	#(1–6), Yes #7, No	508	#(1–6), Yes #7, No
M38A1 Jeep (4 ea.)	DICE THROW[d]	740, 740, 850, and 850	Yes, All	1,113	Yes
M35 Truck/Empty (4 ea.)	DICE THROW[d]	740, 740, 850, and 850	Yes, All	1,004	Yes
M35A2 Truck With Heavy Shelter	DICE THROW[d]	820	Yes	1,103	Yes
M35 Truck With Light Shelter	DICE THROW[d]	1,120	No	1,133	No
M113 APC (3 ea.)	SNOWBALL[b]	473, 570, and 800	Yes, Yes, No	540	Yes, No, Yes

Charge Weights and Types: [a] 5,500 lb/Tritonal; [b] 500 tons/TNT; [c] 100 tons/TNT; [d] 628.3 tons/ANFO.

5. Summary and Recommendations

The Baker Procedure for predicting the overturn of "box-like" targets in blast environments was reviewed and incorporated in a computer program designed to find the (threshold) range from the center of detonation at which the target will just overturn. The target description is simple compared to that required in other overturn procedures; therefore, the Baker Procedure is easier to use, but less accurate. Based on comparisons between case predictions and field test results, it is believed the procedure provides reasonable estimates of the threshold overturn ranges. The procedure could provide a "sanity check" on complex overturn codes. For applications not requiring utmost accuracy, the procedure is useful. These applications could be test layout, posttest analysis, photo interpretation of tests, equipment survivability studies, and wargames.

The following recommendations are designed to increase confidence and to broaden program versatility:

- Small-scale experiments should be conducted to find the accuracy of the procedure.

- The program should be expanded to allow for finding the threshold overturn distance when overpressure and impulse are provided.

- The program should be expanded to allow for finding the charge weight when explosive type and threshold overturn distance are given.

- Additional blast-charge models for specific cases, such as the DICE THROW charge (cylinder, capped with a hemisphere), should be incorporated.

- The program should be expanded to include solving problems for "cylinder-like" targets.

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Appendix A:

Derivation of Prediction Equations (Baker et al. 1977)

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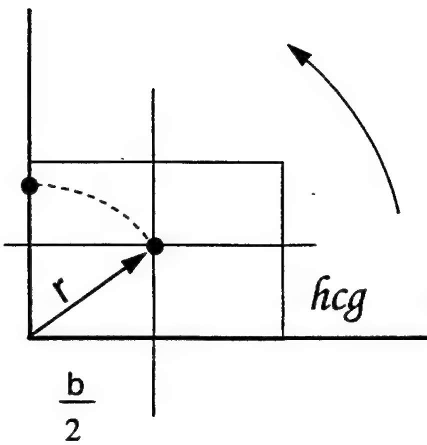
Consider any rigid target, such as a truck, struck on a side by a blast wave. The natural rocking period of such an object can closely be approximated as an inverted pendulum and is very long on the order of seconds. Therefore, the response is in the impulsive loading realm where the target does not move significantly before the blast wave passes. The objective is to determine if the target overturns by comparing the impulse imparted to it to the threshold impulse necessary to just overturn it.

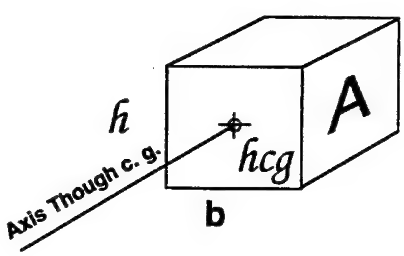
First compute the threshold specific impulse (i_θ). If the target has a total height (h), presented area (A), width (b), a center of gravity (c.g.) height off the ground (h_{cg}), mass (m), and a gravitational field of (g), then the threshold work (W_k) to bring the target to the brink of toppling is the potential energy acquired by the body rotating until the c.g. is vertically above the rotation axis on the ground:



$$W_k = mg\,(r - h_{cg}), \text{ and} \tag{A-1}$$

$$W_k = mg\left(\sqrt{\frac{b^2}{4} + h_{cg}^{\,2}} - h_{cg}\right). \tag{A-2}$$

If mass is fairly uniformly distributed throughout the body, the moment of inertia about a perpendicular axis through the c.g. of a "box-like" target* is just the inertia formula for a rectangular plate width b and height h:

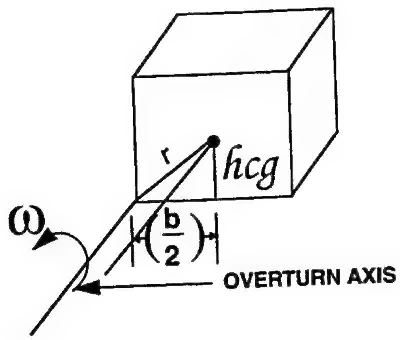


$$J_{cg} = \frac{m}{12}\,(b^2 + h^2). \tag{A-3}$$

Recall that whether a thick or thin plate, depth of mass along the axis makes no difference to inertia.

* "Cylinder-like" targets require a different formula for the moment of inertia.

Transferring the moment of inertia from the c.g. axis to a parallel axis along the rear edge on the ground (for overturning purposes) gives:



$$J = J_{cg} + mr^2, \text{ and} \tag{A-4}$$

$$J = m\left(\frac{b^2}{3} + \frac{h^2}{12} + h_{cg}^2\right). \tag{A-5}$$

Assume toppling with no sliding. The rotational kinetic energy initially imparted to the body equals (1/2) J ω^2, where ω is the initial angular velocity. Substituting for J and equating KE to W_k gives:

$$\omega = \sqrt{2g}\,\frac{\sqrt{\dfrac{W_k}{mg}}}{\sqrt{\dfrac{J}{m}}}. \tag{A-6}$$

Denoting the center of pressure as h_{bl} and applying conservation of angular momentum, one can write:

$$i_\theta A h_{bl} = J\omega. \tag{A-7}$$

Substituting for J and ω plus rearranging terms yields:

$$\frac{i_\theta A h_{bl}}{mg^{1/2} b^{3/2}} = \sqrt{\alpha\beta}, \tag{A-8}$$

where

$$\alpha = \frac{2}{3} + \frac{h^2}{6b^2} + \frac{2h^2}{b^2}\left(\frac{h_{cg}^2}{h^2}\right), \tag{A-9}$$

and

$$\beta = \sqrt{\frac{1}{4} + \frac{h^2}{b^2}\left(\frac{h_{cg}^2}{h^2}\right)} - \frac{h}{b}\left(\frac{h_{cg}}{h}\right). \tag{A-10}$$

Equation A-8 is the relationship plotted in Figure 1.

Next we must compute the impulse i_t imparted to the target. This total impulse is made up of the sum of a diffraction phase of loading and a drag phase of loading. A free-field blast pressure history can be approximated by

$$p(t) = P_s \left(1 - \frac{t}{T}\right) \exp\left(- \frac{t}{T}\right), \tag{A-11}$$

where T is the positive duration. Integrating equation A-11 from zero to T yields the side-on impulse i_s or, conversely, the duration T if P_s and i_s are specified,

$$T = \frac{e\, i_s}{P_s}. \tag{A-12}$$

Actually, we are more interested in the drag pressure q than free-field pressures. A transient drag pressure history is closely approximated by:

$$q(t) = q \left(1 - \frac{t}{T}\right)^2 \exp\left(- \frac{2\,t}{T}\right). \tag{A-13}$$

Integrating equation A-13 gives a drag impulse i_q of:

$$i_q = \frac{qT}{4}\left(1 - \frac{1}{e^2}\right). \tag{A-14}$$

Finally to express i_q as a function of P_s and i_s, we must write q as a function of P_s. This relationship is given by:

$$q = \frac{5 C_D P_S^2}{2(7p_o + P_S)}, \tag{A-15}$$

where C_D is a drag coefficient. Substituting equation A-15 for q and equation A-12 for T into equation A-14 gives the desired drag impulse i_q as a function of P_s and i_s,

$$i_q = \frac{1.47\left(\frac{P_S}{p_o}\right)}{\left(7.0 + \frac{P_S}{p_o}\right)} C_D \, i_S. \tag{A-16}$$

Next, the diffracted impulse i_r must be estimated. This equals

$$i_r = \frac{P_r H}{2U}, \tag{A-17}$$

where U is shock front velocity, P_r is the peak reflected pressure, and H is the smaller of either vehicle height h or vehicle length L. Expressions for U and P_r in terms of P_s are as follows:

$$\left(\frac{U}{a_o}\right)^2 = 1.0 + 0.857 \frac{P_s}{p_o}, \tag{A-18}$$

and

$$\frac{P_r}{P_s} = 2.0 + \frac{6 P_S}{7p_o + P_S}, \tag{A-19}$$

where a_o is the speed of sound in air ahead of the shock. Substituting equations A-18 and A-19 into equation A-17 then yields:

$$i_r = \frac{\left(1.0 + \frac{\frac{3P_s}{p_0}}{7 + \frac{P_s}{p_0}}\right)}{\sqrt{1.0 + 0.857 \frac{P_s}{p_0}}} \frac{P_s H}{a_0}. \tag{A-20}$$

However, i_t is the sum of i_q and i_r. Hence, after adding equations A-14 and A-18 plus multiplying through by (a_o/p_oH), we get:

$$\frac{a_o i_t}{p_o H} = \frac{1.47\ P \left(\dfrac{a_o C_D i_S}{p_o H} \right)}{7.0 + P} + \frac{\left(1.0 + \dfrac{3P}{7.0 + P} \right) P}{\sqrt{1.0 + 0.857\ P}}, \qquad \text{(A-21)}$$

where $P = P_s/p_o$. Equation A-21 is the relationship plotted in Figure 2. Relation A-21 can be put in the simpler form of equation 4 by using the auxiliary functions ζ, η, θ defined in equations 6, 7, and 8, respectively.

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Appendix B:

Predictions of Threshold Overturning Ranges For Targets in Field Tests

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Table of Contents

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Case B1
School Bus - China Lake

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	3.05 m (10 ft)
Track Width or Depth of Base	2.36 m (7.75 ft)
Height of Center of Gravity	1.01 m (3.33 ft)
Presented Area	25.8 m^2 (277.8 ft^2)
Mass of Target	7,030 kg (15,490 lb)

Charge Data Used in Calculation

Charge Geometry	Hemisphere
Explosive Type	Tritonal
TNT Equivalency Factor	1.1
Charge Weight	2.49 × 10 kg (5,500 lb)

Calculational Output

Impulse Threshold for Overturn	1.12 kPa-s (0.162 psi-s)
Impulse Applied to Target	1.14 kPa-s (0.165 psi-s)
Free-Field Overpressure	86.2 kPa (12.5 psi)
Free-Field Impulse	1.14 kPa-s (0.166 psi-s)
RANGE TO OVERTURN THRESHOLD	48 m (159 ft)

Analysis

The target was a body model T-334, manufactured in 1959 by the Blue Bird Body Company of Fort Valley, Georgia.[1] It was placed side-on, 62.5 m (205 ft) from ground zero, a stack of 15 each 750-lb bombs. The vehicle did not overturn. Since the target did not overturn and the range from ground zero to the target (62.5 m) is greater than the prediction (48 m), the procedure is consistent with the test result.

---

[1] Custard, G. H., and J. R. Thayer. "Target Response to Explosive Blast." Falcon Research and Development, Denver, CO, September 1970. (AD 715475)

Case B2
Pickup With Camper - China Lake

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	2.3 m (7.5 ft)
Track Width or Depth of Base	1.73 m (5.67 ft)
Height of Center of Gravity	0.91 m (3 ft)
Presented Area	7.66 m^2 (82.4 ft^2)
Mass of Target	2,270 kg (5,000 lb)

Charge Data Used in Calculation

Charge Geometry	Hemisphere
Explosive Type	Tritonal
TNT Equivalency Factor	1.1
Charge Weight	2.5×10^3 kg (5,500 lb)

Calculational Output

Impulse Threshold for Overturn	1.01 kPa-s (0.147 psi-s)
Impulse Applied to Target	1.02 kPa-s (0.148 psi-s)
Free-Field Overpressure	93.8 kPa (13.6 psi)
Free-Field Impulse	1.19 kPa-s (0.172 psi-s)
RANGE TO OVERTURN THRESHOLD	47 m (153 ft)

Analysis

The target consisted of a pickup truck with a camper.[1] The truck was a U.S. Army M37 cargo truck, 1953 Dodge, model T-245, rated at 3/4-ton capacity with 4 × 4 drive. The camper was made of plywood and sheet aluminum and was securely attached to the truck bed. It was placed side-on, 55 m (180 ft) from ground zero, a stack of 15 each 750-lb bombs. The vehicle did not overturn, but the camper/truck bed separated from the truck. Since the target did not overturn and the range from ground zero to the target (55 m) is greater than the prediction (47 m), the procedure is consistent with the test result.

---

[1] Custard, G. H., and J. R. Thayer. "Target Response to Explosive Blast." Falcon Research and Development, Denver, CO, September 1970. (AD 715475)

Case B3
Bus (Large) - DIAL PACK Event

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	2.67 m (8.75 ft)
Track Width or Depth of Base	2.23 m (7.33 ft)
Height of Center of Gravity	0.97 m (3.17 ft)
Presented Area	14 m^2 (151.4 ft^2)
Mass of Target	5,630 kg (12,400 lb)

Charge Data Used in Calculation

Charge Geometry	Sphere
Explosive Type	TNT
TNT Equivalency Factor	1
Charge Weight	4.54×10^5 kg (1×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	1.7 kPa-s (0.246 psi-s)
Impulse Applied to Target	1.72 kPa-s (0.247 psi-s)
Free-Field Overpressure	66 kPa (9.3 psi)
Free-Field Impulse	5.33 kPa-s (0.781 psi-s)
RANGE TO OVERTURN THRESHOLD	318 m (1,044 ft)

Analysis

The target was tested at the DIAL PACK event, which was conducted on 23 July 1970, at the Suffield Experiment Station, Ralston, Alberta, Canada.[1] The vehicle was a 1951 Reo, model F-122, 55-passenger school bus. The vehicle was placed side-on, 366 m (1,200 ft) from ground zero and did not overturn. Since the target did not overturn and the range from ground zero to the target (366 m) is greater than the prediction (318 m), the procedure is consistent with the test result.

[1] Custard, G. H., and J. R. Thayer. "Target Response to Explosive Blast." Falcon Research and Development, Denver, CO, September 1970. (AD 715475)

Case B4
Bus (Small) - DIAL PACK Event

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	2.39 m (7.83 ft)
Track Width or Depth of Base	1.78 m (5.83 ft)
Height of Center of Gravity	0.86 m (2.83 ft)
Presented Area	8.5 m^2 (92 ft^2)
Mass of Target	3,000 kg (6,500 lb)

Charge Data Used in Calculation

Charge Geometry	Sphere
Explosive Type	TNT
TNT Equivalency Factor	1
Charge Weight	4.54×10^5 kg (1×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	1.19 kPa-s (0.172 psi-s)
Impulse Applied to Target	1.19 kPa-s (0.173 psi-s)
Free-Field Overpressure	52 kPa (7.60 psi)
Free-Field Impulse	4.46 kPa-s (0.647 psi-s)
RANGE TO OVERTURN THRESHOLD	394 m (1,294 ft)

Analysis

The target was tested at the DIAL PACK event, which was conducted on 23 July 1970, at the Suffield Experiment Station, Ralston, Alberta, Canada.[1] The vehicle was a 1957 GMC, 20-passenger school bus. The vehicle was placed side-on 914 m (3,000 ft) from ground zero and did not overturn. Since the target did not overturn and the range from ground zero to the target (914 m) is greater than the prediction (394 m), the procedure is consistent with the test result.

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[1] Custard, G. H., and J. R. Thayer. "Target Response to Explosive Blast." Falcon Research and Development, Denver, CO, September 1970. (AD 715475)

Case B5
M38A1 Jeep - Suffield 100T

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	1.2 m (3.94 ft)
Track Width or Depth of Base	1.42 m (4.68 ft)
Height of Center of Gravity	0.70 m (2.29 ft)
Presented Area	3.96 m^2 (42.7 ft^2)
Mass of Target	1,171 kg (2,582 lb)

Charge Data Used in Calculation

Charge Geometry	Hemisphere
Explosive Type	TNT
TNT Equivalency Factor	1
Charge Weight	9.07×10^4 kg (2×10^5 lb)

Calculational Output

Impulse Threshold for Overturn	1.36 kPa-s (0.197 psi-s)
Impulse Applied to Target	1.39 kPa-s (0.202 psi-s)
Free-Field Overpressure	87.6 kPa (12.7 psi)
Free-Field Impulse	3.70 kPa-s (0.537 psi-s)
RANGE TO OVERTURN THRESHOLD	155 m (508 ft)

Analysis

The target was the U.S. Army M38A1, 1/4-ton utility truck ("Jeep"). Seven copies of the M38A1 were tested at the 100-ton TNT charge event,[2] which was conducted on 3 August 1961, at the Suffield Experiment Station, Ralston, Alberta, Canada. The vehicles were placed side-on at the following distances from ground zero: 91.4 m (300 ft) (2 ea.), 111 m (365 ft) (2 ea.), 129 m (424 ft) (2 ea.), and 151 m (495 ft) (1 ea.). All of the vehicles overturned, except the last. Since six of the targets overturned and the ranges from ground zero to those targets (91.4 m, 111 m, and 129 m) were less than the prediction (155 m), the procedure is consistent with the test results. The target at 151 m did not overturn, and the target range was less than the prediction, so the procedure is not consistent with this result.

[2] Lee, W. N., and T. A. Dalton. "Blast Overturning Analysis of Four Army Vehicles Using TRUCK 3.0." BRL-CR-00479, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, pp. 32, 33, 51, and 83, April 1982. (AD B064178L)

Case B6
M38A1 Jeep - DICE THROW Event

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	1.2 m (3.94 ft)
Track Width or Depth of Base	1.42 m (4.68 ft)
Height of Center of Gravity	0.58 m (1.91 ft)
Presented Area	3.96 m^2 (42.7 ft^2)
Mass of Target	1,142 kg (2,518 lb)

Charge Data Used in Calculation

Charge Geometry	Cylinder
Explosive Type	AN/FO
TNT Equivalency Factor	0.874
Charge Weight	5.7×10^5 kg (1.2566×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	1.32 kPa-s (0.192 psi-s)
Impulse Applied to Target	1.34 kPa-s (0.195 psi-s)
Free-Field Overpressure	73.8 kPa (10.7 psi)
Free-Field Impulse	4.27 kPa-s (0.620 psi-s)
RANGE TO OVERTURN THRESHOLD	339 m (1,113 ft)

Analysis

Jeeps were tested at the DICE THROW event,[2] which was conducted at White Sands Missile Range on 6 October 1976. Two vehicles were placed side-on 226 m (740 ft) and two vehicles were placed side-on 259 m (850 ft) from ground zero. All of the vehicles overturned. Since all of the targets overturned and the ranges from ground zero to the targets (226 m and 259 m) were less than the prediction (339 m), the procedure is consistent with the test results.

---

[2] Lee, W. N., and T. A. Dalton. "Blast Overturning Analysis of Four Army Vehicles Using TRUCK 3.0." BRL-CR-00479, U.S Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, pp. 32, 33, 51, and 80, April 1982. (AD B064178L)

Case B7
M35 Truck/Empty - DICE THROW Event

Target Data Used in Calculation*

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	2.05 m (6.75 ft)
Track Width or Depth of Base	2.36 m (7.75 ft)
Height of Center of Gravity	0.95 m (3.12 ft)
Presented Area	15.8 m^2 (170.6 ft^2)
Mass of Target	5,654 kg (12,465 lb)

Charge Data Used in Calculation

Charge Geometry	Cylinder
Explosive Type	AN/FO
TNT Equivalency Factor	0.874
Charge Weight	5.7×10^5 kg (1.2566×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	2.04 kPa-s (0.296 psi-s)
Impulse Applied to Target	2.05 kPa-s (0.298 psi-s)
Free-Field Overpressure	93.7 kPa (13.6 psi)
Free-Field Impulse	4.73 kPa-s (0.687 psi-s)
RANGE TO OVERTURN THRESHOLD	306 m (1,004 ft)

Analysis

Unloaded M35 cargo trucks, 2 1/2-ton, 6x6, were tested at the DICE THROW event.[2] Two vehicles were placed side-on, 226 m (740 ft) and two vehicles were placed side-on, 259 m (850 ft) from ground zero. All of the vehicles overturned. Since all of the targets overturned and the ranges from ground zero to the targets (226 m and 259 m) were less than the prediction (306 m), the procedure is consistent with the test results.

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*Baker's example (p. 4) uses different target data. Case B7 may be closer to correct.

[2] Lee, W. N., and T. A. Dalton. "Blast Overturning Analysis of Four Army Vehicles Using TRUCK 3.0." BRL-CR-00479, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, pp. 42, 43, and 51, April 1982. (AD B064178L)

Case B8
M35A2 Truck With Heavy Shelter - DICE THROW Event

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	3.33 m (10.92 ft)
Track Width or Depth of Base	2.36 m (7.75 ft)
Height of Center of Gravity	1.32 m (4.34 ft)
Presented Area	17.4 m^2 (187 ft^2)
Mass of Target	8,437 kg (18,602 lb)

Charge Data Used in Calculation

Charge Geometry	Cylinder
Explosive Type	AN/FO
TNT Equivalency Factor	0.874
Charge Weight	5.7×10^5 kg (1.2566×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	1.85 kPa-s (0.268 psi-s)
Impulse Applied to Target	1.86 kPa-s (0.271 psi-s)
Free-Field Overpressure	75.9 kPa (11.0 psi)
Free-Field Impulse	4.31 kPa-s (0.625 psi-s)
RANGE TO OVERTURN THRESHOLD	336 m (1,103 ft)

Analysis

An M35A2 truck loaded with a 6,200-lb, S-280 communication shelter was tested at DICE THROW event.[2] The vehicle was placed side-on, 250 m (820 ft) from ground zero and it overturned. Since the target overturned and the range from ground zero to the target (250 m) was less than the prediction (336 m), the procedure is consistent with the test result.

[2] Lee, W. N., and T. A. Dalton. "Blast Overturning Analysis of Four Army Vehicles Using TRUCK 3.0." BRL-CR-00479, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, pp. 19, 29, 51, and 76, April 1982. (AD B064178L)

Case B9
M35 Truck With Light Shelter - DICE THROW Event

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	3.33 m (10.92 ft)
Track Width or Depth of Base	2.36 m (7.75 ft)
Height of Center of Gravity	1.21 m (3.98 ft)
Presented Area	17.4 m^2 (187 ft^2)
Mass of Target	7,922 kg (17,465 lb)

Charge Data Used in Calculation

Charge Geometry	Cylinder
Explosive Type	AN/FO
TNT Equivalency Factor	0.874
Charge Weight	5.7×10^5 kg (1.2566×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	1.74 kPa-s (0.252 psi-s)
Impulse Applied to Target	1.74 kPa-s (0.252 psi-s)
Free-Field Overpressure	71.0 kPa (10.3 psi)
Free-Field Impulse	4.20 kPa-s (0.609 psi-s)
RANGE TO OVERTURN THRESHOLD	345 m (1,133 ft)

Analysis

An M35 truck loaded with a 5,000-lb, S-280 communication shelter was tested at the DICE THROW event.[2] The vehicle was placed side-on, 341 m (1,120 ft) from ground zero and did not overturn. Since the target did not overturn and the range from ground zero to the target (341 m) is less than the prediction (345 m), the procedure is not consistent with the test result.

[2] Lee, W. N., and T. A. Dalton. "Blast Overturning Analysis of Four Army Vehicles Using TRUCK 3.0." BRL-CR-00479, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, pp. 19, 29, 51, and 76, April 1982. (AD B064178L)

Case B10
M113 APC/Stripped - SNOWBALL Event

Target Data Used in Calculation

Air Drag Coefficient (subjectively determined from Table 1)	1.8
Total Height of Target	1.82 m (6.0 ft)
Track Width or Depth of Base	2.56 m (8.41 ft)
Height of Center of Gravity	1.01 m (3.32 ft)
Presented Area	8.46 m^2 (91.1 ft^2)
Mass of Target	9,299 kg (20,500 lb)

Charge Data Used in Calculation

Charge Geometry	Hemisphere
Explosive Type	TNT
TNT Equivalency Factor	1
Charge Weight	4.54×10^5 kg (1×10^6 lb)

Calculational Output

Impulse Threshold for Overturn	7.85 kPa-s (1.14 psi-s)
Impulse Applied to Target	8.13 kPa-s (1.18 psi-s)
Free-Field Overpressure	249 kPa (36.2 psi)
Free-Field Impulse	9.72 kPa-s (1.41 psi-s)
RANGE TO OVERTURN THRESHOLD	165 m (540 ft)

Analysis

Three M113 armored personnel carriers were tested at the SNOWBALL event,[2] which was conducted on 17 July 1964, at the Suffield Experiment Station, Ralston, Alberta, Canada. Vehicles were placed side-on, 144 m (473 ft), 174 m (570 ft), and 244 m (800 ft) from ground zero. The Baker Procedure is only partially supported by these experiments. Since the first target did overturn and the range from ground zero to the target (144 m) is less than the prediction (165 m), the procedure is consistent with the test result. Since the second target did overturn and the range from ground zero to the target (174 m) is greater than the prediction (165 m), the procedure is not consistent with the test result. Since the third target did not overturn and the range from ground zero to the target (244 m) is greater than the prediction (165 m), the procedure is consistent with the test result.

---

[2] Lee, W. N., and T. A. Dalton. "Blast Overturning Analysis of Four Army Vehicles Using TRUCK 3.0." BRL-CR-00479, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, pp. 45, 46, and 51, April 1982. (AD B064178L)

Appendix C:

Overturn Prediction Computer Program

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THE OVERTURN SETUP PROGRAM

```
10 REM @@@  PROGRAM OTSETUP.TEM @@@
20 REM @@@  CHARGE CHARACTERISTICS  @@@
30 OPEN "R",#1,"CHARGE":CODE%=1
40 FIELD#1,20 AS C$, 5 AS G$, 20 AS P$, 5 AS E$, 5 AS W$
50 GET #1,CODE%
60 CGS$="Hemisphere":GEO=1:TYP$="TNT":EF=1:CW=1
70 LSET C$=CHG$:LSET G$=MKS$(GEO):LSET P$=TYP$
80 LSET E$=MKS$(EF):LSET W$=MSK$(CW)
90 PUT #1,CODE%
100 CLOSE #1
110 REM
120 REM @@@  SETUP FOR CHARGE ID NUMBERS @@@
130 CLS:CODE%=0
140 FOR J= 1 TO 10
150 OPEN "R",#1,"GEOMETRY"
160 FIELD#1,20 AS N$, 5 AS G$
170 CODE%=CODE%+1
180 IF CODE%>1 THEN 200
190 NAM$="Hemisphere":GEO=CODE%:GOTO 370
200 IF CODE%>2 THEN 220
210 NAM$="Cylinder-(L/D)(3 to 12)":GEO=CODE%:GOTO 370
220 IF CODE%>3 THEN 240
230 NAM$="Spherical-Free Air":GEO=CODE%:GOTO 370
240 IF CODE%>4 THEN 260
250 NAM$="BLANK":GEO=CODE%:GOTO 370
260 IF CODE%>5 THEN 280
270 NAM$="BLANK":GEO=CODE%:GOTO 370
280 IF CODE%>6 THEN 300
290 NAM$="BLANK":GEO=CODE%:GOTO 370
300 IF CODE%>7 THEN 320
310 NAM$="BLANK":GEO=CODE%:GOTO 370
320 IF CODE%>8 THEN 340
330 NAM$="BLANK":GEO=CODE%:GOTO 370
340 IF CODE%>9 THEN 360
350 NAM$="BLANK":GEO=CODE%:GOTO 370
360 NAM$="BLANK":GEO=CODE%
370 LOCATE CODE%+5,20:PRINT NAM$
375 LOCATE CODE%+5,50:PRINT GEO
380 LSET N$=NAM$:LSET G$=MKS$(GEO)
390 PUT #1, CODE%
400 CLOSE #1
410 NEXT J
420 REM @@@ TYPES OF EXPLOSIVES AND TNT EQUIVALENCY FACTORS @@@@
```

```
430 GOTO 510
440 OPEN "R", #1,"CHGTYPE"
450 FIELD#1,5 AS E$, 20 AS C$
460 LSET E$=MKS$(EF):LSET C$=CT$
470 PUT #1,CODE%
480 PRINT CODE%,"EF=";EF,"TYPE=";CT$
490 CLOSE #1
500 RETURN
510 CODE%=1:EF=1:CT$="TNT":GOSUB 440
515 CODE%=39:EF=.874:CT$="AN/FO":GOSUB 440
520 CODE%=2:EF=.525:CT$="BARATOL":GOSUB 440
530 CODE%=3:EF=.283:CT$="BORACITOL":GOSUB 440
540 CODE%=4:EF=1.198:CT$="BTF":GOSUB 440
550 CODE%=5:EF=1.092:CT$="COMP B":GOSUB 440
560 CODE%=6:EF=1.129:CT$="COMP C4":GOSUB 440
570 CODE%=7:EF=1.115:CT$="CYCLOTOL 75/25":GOSUB 440
580 CODE%=8:EF=.893:CT$="DATR/DATNB":GOSUB 440
590 CODE%=9:EF=.959:CT$="DIPAM":GOSUB 440
600 CODE%=10:EF=.752:CT$="DNPA":GOSUB 440
610 CODE%=11:EF=.874:CT$="EDNP":GOSUB 440
620 CODE%=12:EF=1.149:CT$="FEFO":GOSUB 440
630 CODE%=13:EF=1.042:CT$="HMX":GOSUB 440
640 CODE%=14:EF=1.044:CT$="HNAB":GOSUB 440
650 CODE%=15:EF=1.009:CT$="HNS":GOSUB 440
660 CODE%=16:EF=1.222:CT$="LX-01":GOSUB 440
670 CODE%=17:EF=1.009:CT$="LX-02-1":GOSUB 440
680 CODE%=18:EF=1.007:CT$="LX-04":GOSUB 440
690 CODE%=19:EF=1.058:CT$="LX-07":GOSUB 440
700 CODE%=20:EF=1.406:CT$="LX-08":GOSUB 440
710 CODE%=21:EF=1.136:CT$="LX-09-1":GOSUB 440
720 CODE%=22:EF=1.101:CT$="LX-10-0":GOSUB 440
730 CODE%=23:EF=.874:CT$="LX-11-0":GOSUB 440
740 CODE%=24:EF=1.119:CT$="LX-14":GOSUB 440
750 CODE%=25:EF=1.136:CT$="NG":GOSUB 440
760 CODE%=26:EF=.752:CT$="NQ":GOSUB 440
770 CODE%=27:EF=1.113:CT$="OCTOL 70/30":GOSUB 440
780 CODE%=28:EF=1.108:CT$="PBX-9007":GOSUB 440
790 CODE%=29:EF=1.044:CT$="PBX-9010":GOSUB 440
800 CODE%=30:EF=1.087:CT$="PBX-9011":GOSUB 440
810 CODE%=31:EF=1.037:CT$="PBX-9205":GOSUB 440
820 CODE%=32:EF=1.108:CT$="PBX-9404":GOSUB 440
830 CODE%=33:EF=1.136:CT$="PBX-9407":GOSUB 440
840 CODE%=34:EF=1.129:CT$="PBX-9501":GOSUB 440
850 CODE%=35:EF=1.085:CT$="PENTOLITE 50/50":GOSUB 440
860 CODE%=36:EF=1.169:CT$="PETN":GOSUB 440
```

```
870 CODE%=37:EF=1.149:CT$="RDX":GOSUB 440
880 CODE%=38:EF=1.071:CT$="TETRYL":GOSUB 440
882 CODE%=40:EF=1.2:CT$="TETRYTOL":GOSUB 440
884 CODE%=41:EF=1.1:CT$="TRITONAL":GOSUB 440
890 GOTO 1140
900 REM INPUT DATA FOR 1 LB TNT HEMISPHERE BLAST PARAMETERS
910 DATA 1.70E-01,8.04E+03,3.30E-01,1.80E-01,7.64E+03,2.99E-01
920 DATA 2.00E-01,6.96E+03,2.47E-01,2.50E-01,5.63E+03,1.59E-01
930 DATA 3.00E-01,4.65E+03,1.10E-01,3.50E-01,3.91E+03,8.02E-02
940 DATA 4.00E-01,3.34E+03,6.19E-02,4.50E-01,2.89E+03,4.99E-02
950 DATA 5.00E-01,2.54E+03,4.17E-02,6.00E-01,2.01E+03,3.16E-02
960 DATA 7.00E-01,1.64E+03,2.61E-02,8.00E-01,1.37E+03,2.28E-02
970 DATA 9.00E-01,1.16E+03,2.08E-02,1.00E+00,1.00E+03,1.96E-02
980 DATA 1.20E+00,7.63E+02,1.86E-02,1.40E+00,5.97E+02,1.87E-02
990 DATA 1.60E+00,4.75E+02,1.94E-02,1.80E+00,3.84E+02,2.07E-02
1000 DATA 2.00E+00,3.15E+02,2.23E-02,2.50E+00,2.00E+02,2.64E-02
1010 DATA 3.00E+00,1.35E+02,2.40E-02,3.50E+00,9.53E+01,2.12E-02
1020 DATA 4.00E+00,7.02E+01,1.87E-02,4.50E+00,5.35E+01,1.67E-02
1030 DATA 5.00E+00,4.19E+01,1.51E-02,6.00E+00,2.77E+01,1.27E-02
1040 DATA 7.00E+00,1.98E+01,1.11E-02,8.00E+00,1.49E+01,9.84E-03
1050 DATA 9.00E+00,1.17E+01,8.88E-03,1.00E+01,9.56E+00,8.10E-03
1060 DATA 1.20E+01,6.83E+00,6.90E-03,1.40E+01,5.23E+00,6.01E-03
1070 DATA 1.60E+01,4.21E+00,5.32E-03,1.80E+01,3.50E+00,4.77E-03
1080 DATA 2.00E+01,2.99E+00,4.31E-03,2.50E+01,2.17E+00,3.40E-03
1090 DATA 3.00E+01,1.70E+00,2.92E-03,3.50E+01,1.39E+00,2.52E-03
1100 DATA 4.00E+01,1.18E+00,2.21E-03,4.50E+01,1.01E+00,1.97E-03
1110 DATA 5.00E+01,8.89E-01,1.78E-03,6.00E+01,7.05E-01,1.49E-03
1120 DATA 7.00E+01,5.75E-01,1.28E-03,8.00E+01,4.77E-01,1.12E-03
1130 DATA 9.00E+01,4.03E-01,9.92E-04,1.00E+02,3.47E-01,8.90E-04
1140 CODE%=0
1150 FOR J=1 TO 46
1160 OPEN "R", #1, "CHGHEMIS"
1170 FIELD#1, 10 AS D$, 10 AS P$, 10 AS I$
1180 CODE%=CODE%+1
1190 READ DDD,PPP,III
1200 LSET D$=MKS$(DDD):LSET P$=MKS$(PPP):LSET I$=MKS$(III)
1210 PUT #1,CODE%
1220 PRINT DDD;PPP;III
1230 CLOSE #1
1240 NEXT J
1250 REM INPUT DATA FOR 1 LB TNT SPHERICAL AIR BURST BLAST
PARAMETERS
1260 DATA 1.34E-01,7.10E+03,2.90E-01,1.40E-01,6.93E+03,2.70E-01
1270 DATA 1.60E-01,6.37E+03,2.14E-01,1.80E-01,5.87E+03,1.71E-01
1280 DATA 2.00E-01,5.42E+03,1.39E-01,2.50E-01,4.50E+03,8.79E-02
```

```
1290 DATA 3.00E-01,3.82E+03,6.08E-02,3.50E-01,3.29E+03,4.53E-02
1300 DATA 4.00E-01,2.87E+03,3.58E-02,4.50E-01,2.53E+03,2.96E-02
1310 DATA 5.00E-01,2.24E+03,2.54E-02,6.00E-01,1.79E+03,2.04E-02
1320 DATA 7.00E-01,1.46E+03,1.77E-02,8.00E-01,1.20E+03,1.63E-02
1330 DATA 9.00E-01,1.00E+03,1.55E-02,1.00E+00,8.45E+02,1.52E-02
1340 DATA 1.20E+00,6.16E+02,1.55E-02,1.40E+00,4.63E+02,1.65E-02
1350 DATA 1.60E+00,3.56E+02,1.80E-02,1.80E+00,2.80E+02,1.98E-02
1360 DATA 2.00E+00,2.25E+02,2.18E-02,2.50E+00,1.38E+02,1.96E-02
1370 DATA 3.00E+00,9.17E+01,1.67E-02,3.50E+00,6.45E+01,1.44E-02
1380 DATA 4.00E+00,4.76E+01,1.27E-02,4.50E+00,3.64E+01,1.14E-02
1390 DATA 5.00E+00,2.88E+01,1.03E-02,6.00E+00,1.93E+01,8.79E-03
1400 DATA 7.00E+00,1.39E+01,7.67E-03,8.00E+00,1.06E+01,6.82E-03
1410 DATA 9.00E+00,8.37E+00,6.14E-03,1.00E+01,8.86E+00,5.59E-03
1420 DATA 1.20E+01,4.94E+00,4.74E-03,1.40E+01,3.81E+00,4.11E-03
1430 DATA 1.60E+01,3.08E+00,3.62E-03,1.80E+01,2.58E+00,3.24E-03
1440 DATA 2.00E+01,2.21E+00,2.94E-03,2.50E+01,1.63E+00,2.37E-03
1450 DATA 3.00E+01,1.28E+00,1.99E-03,3.50E+01,1.05E+00,1.72E-03
1460 DATA 4.00E+01,8.79E-01,1.51E-03,4.50E+01,7.52E-01,1.34E-03
1470 DATA 5.00E+01,6.53E-01,1.21E-03,6.00E+01,5.08E-01,1.01E-03
1480 DATA 7.00E+01,4.10E-01,8.63E-04,8.00E+01,3.40E-01,7.54E-04
1490 DATA 9.00E+01,2.89E-01,6.67E-04,1.00E+02,2.52E-01,5.96E-04
1500 CODE%=0
1510 FOR J=1 TO 48
1520 OPEN "R", #1, "CHGSPHER"
1530 FIELD#1, 10 AS D$, 10 AS P$, 10 AS I$
1540 CODE%=CODE%+1
1550 READ DDD,PPP,III
1560 LSET D$=MKS$(DDD):LSET P$=MKS$(PPP):LSET I$=MKS$(III)
1570 PUT #1,CODE%
1580 PRINT DDD;PPP;III
1590 REM LPRINT DDD;PPP;III
1600 CLOSE #1
1610 NEXT J
1640 END
```

THE MAIN OVERTURN PROGRAM

```
10 REM @@@ C:\BASIC\BLAST\OVERTURN.TEM @@@
20 CLS:COLOR 14,,4:LOCATE 10,20:PRINT "THIS PROGRAM DETERMINES THE MAXIMUM"
30 LOCATE 12,20:PRINT "RANGE A TARGET WILL OVERTURN WHEN"
40 LOCATE 14,20:PRINT "SUBJECTED TO A BLAST ENVIRONMENT!"
50 FOR J=1 TO 2:BEEP:NEXT J
60 CLS:LOCATE 2,10:COLOR 10:PRINT "TYPE CODE% FOR DESIRED TARGET":COLOR 14
70 G=32:AAP=14.7:ASV=1079
80 CODE%=0:LOCATE 4,5:PRINT "CODE%" TAB(15) "TARGET"
90 LOCATE 4,40:PRINT "CODE%" TAB(50) "TARGET"
100 FOR J=1 TO 30
110 OPEN "R",#1,"DATAFILE"
120  FIELD#1,20 AS N$
130 CODE%=CODE%+1
140 GET #1, CODE%
150 T$=N$:IF CODE%<16 THEN LOCATE CODE%+5,5
160 IF CODE%<16 THEN PRINT CODE%;"-";T$:GOTO 180
170 LOCATE CODE%-10,40:PRINT CODE%;"-";T$
180 CLOSE #1
190 NEXT J
200 INPUT TARTYP
210 CODE%=TARTYP
220 CLS
230 OPEN "R",#1,"DATAFILE"
240 FIELD#1,20 AS N$, 5 AS ADC$, 5 AS HH$, 5 AS DEPTH$, 5 AS HCG$, 5 AS AREA$, 10 AS M$, 10 AS CW$
250 GET #1, CODE%
260 T$ = N$
270 ADC=CVS(ADC$):HH=CVS(HH$):DEPTH=CVS(DEPTH$)
280 HCG=CVS(HCG$):AREA=CVS(AREA$):M=CVS(M$):CW=CVS(CW$)
290 GOTO 390
300 LOCATE 1+7,10:PRINT "Target -":LOCATE 1+7,20:PRINT T$
310 COLOR 14:LOCATE 3+7,30:PRINT "TARGET CHARACTERISTICS"
320 LOCATE 5+7,20:PRINT"Air Drag Coefficient (ADC) =":LOCATE 5+7,71:PRINT ADC
330 LOCATE 6+7,20:PRINT"Total height of the target (ft) =":LOCATE 6+7,71:PRINT HH
340 LOCATE 7+7,20:PRINT"Track width or depth of the base (ft) =":LOCATE 7+7,71:PRINT DEPTH
350 LOCATE 8+7,20:PRINT"Height of the center of gravity (ft) =":LOCATE 8+7,71:PRINT HCG
360 LOCATE 9+7,20:PRINT"Presented area (sq.ft) =":LOCATE 9+7,71:PRINT AREA
370 LOCATE 10+7,20:PRINT"Mass of the target (lbs) =":LOCATE 10+7,71:PRINT M
380 RETURN
390 GOSUB 300
```

```
400 LOCATE 1+5,5:COLOR 10:PRINT "Is this the intended target?   (y or n)"
410 INPUT NNN$:COLOR 14:IF NNN$="n" THEN 710
420 IF NNN$="y" THEN 430 ELSE 400
430 CLS:GOSUB 300:LOCATE 1+5,5:COLOR 10
440 PRINT "Do you wish to change the name of the target? (y or n)"
450 INPUT NN$:COLOR 14:IF NN$="n" THEN 540
460 IF NN$="y" THEN 470 ELSE 430
470 CLS:GOSUB 300:LOCATE 1+5,5:COLOR 10
480 PRINT " Type in the appropriate name for the target!"
490 INPUT NN$:COLOR 14:T$=NN$:GOSUB 300:GOTO 540
500 CLS:GOSUB 300:COLOR 10:LOCATE 1+4,10
510 PRINT "Taking one at a time, are the following characteristics correct?"
520 LOCATE 1+5,5:PRINT "If correct, press 'Enter', if not, type desired value."
530 RETURN
540 GOSUB 500
550 LOCATE 5+7,70:COLOR 10:INPUT X:IF X=0 THEN COLOR 14:GOTO 570
560 ADC=X:CLS:GOSUB 500:COLOR 14:GOSUB 300
570 CLS:GOSUB 500:GOSUB 300:LOCATE 6+7,70:COLOR 10:INPUT X:IF X=0 THEN COLOR
14:GOTO 590
580 HH=X:CLS:GOSUB 500:COLOR 14:GOSUB 300
590 CLS:GOSUB 500:GOSUB 300:LOCATE 7+7,70:COLOR 10:INPUT X:IF X=0 THEN COLOR
14:GOTO 610
600 DEPTH=X:CLS:GOSUB 500:COLOR 14:GOSUB 300
610 CLS:GOSUB 500:GOSUB 300:LOCATE 8+7,70:COLOR 10:INPUT X:IF X=0 THEN COLOR
14:GOTO 630
620 HCG=X:CLS:GOSUB 500:COLOR 14:GOSUB 300
630 CLS:GOSUB 500:GOSUB 300:LOCATE 9+7,70:COLOR 10:INPUT X:IF X=0 THEN COLOR
14:GOTO 650
640 AREA=X:CLS:GOSUB 500:COLOR 14:GOSUB 300
650 CLS:GOSUB 500:GOSUB 300:LOCATE 10+7,70:COLOR 10:INPUT X:IF X=0 THEN
COLOR 14:GOTO 670
660 M=X:CLS:GOSUB 500:COLOR 14:GOSUB 300
670 LSET N$=T$
680 LSET ADC$=MKS$(ADC):LSET HH$=MKS$(HH):LSET DEPTH$=MKS$(DEPTH)
690 LSET HCG$=MKS$(HCG):LSET AREA$=MKS$(AREA):LSET M$=MKS$(M):LSET
CW$=MKS$(CW)
700 PUT #1,CODE%
710 CLOSE #1
720 IF NNN$="n" THEN 60 ELSE 730
730 H=HH
740 REM   " DETERMINATION OF SCALED THRESHOLD OVERTURNING IMPULSE -
STOI"
750 STH=HH/DEPTH:SCGH=HCG/HH
760 BETA =((1/4)+STH^2*SCGH^2)^(1/2)-STH*SCGH
770 ALPHA=(2/3)+(1/6)*STH^2+2*STH^2*SCGH^2
```

```
780 STOI=(ALPHA*BETA)^(1/2)
790 REM   " DETERMINATION OF THRESHOLD IMPULSE FOR OVERTURNING - OASI"
800 AA=AREA*144:HBL=HH/2:MM=M/G:GG=G^(.5):DD=(DEPTH)^(1.5)
810 OASI=(STOI*MM*GG*DD)/(AA*HBL)
820 GOTO 970
830 REM @@@ S/R FOR PRINTING CHARGE CHARACTERISTICS ON SCREEN @@@
840 CLS:LOCATE 5,30:PRINT "CHARGE CHARACTERISTICS"
850 OPEN "R",#1,"CHARGE":CODE%=1
860 FIELD#1,20 AS C$, 5 AS G$, 20 AS P$, 5 AS E$, 5 AS W$
870 GET #1,CODE%
880 CHG$=C$:GEO=CVS(G$):TYP$=P$:EF=CVS(E$):CW=CVS(W$)
890 LOCATE 9,20:PRINT "Geometry":LOCATE 9,50:PRINT CHG$
900 REM LOCATE 8,20:PRINT "Charge ID. Number":LOCATE 8,50:PRINT GEO
910 LOCATE 10,20:PRINT "Explosive":LOCATE 10,50:PRINT TYP$
920 LOCATE 11,20:PRINT "TNT Equivalency Factor":LOCATE 11,50 :PRINT EF
930 LOCATE 12,20:PRINT "Weight":LOCATE 12,50:PRINT CW;"lbs"
940 CLOSE #1
950 RETURN
960 REM @@@@@@@@@@  END OF S/R  @@@@@@@@@@
970 GOSUB 830
980 LOCATE 9,5:COLOR 10:PRINT "Ok - (y/n)":LOCATE 9,16:INPUT X$:COLOR 14
990 IF X$="n" THEN 1020
1000 IF X$="y" THEN 1290
1010 GOTO 980
1020 CLS:CODE%=0:LOCATE 8,20:PRINT "ID NUMBERS VERSUS CHARGE GEOMETRY"
1030 FOR J= 1 TO 10
1040 OPEN "R",#1,"GEOMETRY"
1050 FIELD#1,20 AS N$, 5 AS G$
1060 CODE%=CODE%+1:GET #1,CODE%
1070 NAM$=N$:GEO=CVS(G$)
1080 LOCATE 10+CODE%,20:PRINT NAM$;GEO
1090 CLOSE #1
1100 NEXT J
1110 LOCATE 23,1:COLOR 10,0,4:PRINT "TYPE CORRECT ID NUMBER!":LOCATE 23,30
1120 INPUT GGG:COLOR 14
1130 CODE%=GGG
1140 OPEN "R",#1,"GEOMETRY"
1150 FIELD#1,20 AS N$, 5 AS G$
1160 GET #1,CODE%
1170 NAM$=N$
1180 CLOSE #1
1190 REM @@@ CORRECTING GEOMETRY INDICATION  @@@
1200 CLS:LOCATE 5,30:PRINT "CHARGE CHARACTERISTICS"
1210 OPEN "R",#1,"CHARGE":CODE%=1
1220 FIELD#1,20 AS C$, 5 AS G$, 20 AS P$, 5 AS E$, 5 AS W$
```

```
1230 GET #1,CODE%
1240 CHG$=C$:GEO=CVS(G$):TYP$=P$:EF=CVS(E$):CW=CVS(W$)
1250 CHG$=NAM$:GEO=GGG
1260 LSET C$=CHG$:LSET G$=MKS$(GEO):LSET P$=TYP$:LSET E$=MKS$(EF):LSET
W$=MKS$(CW)
1270 PUT #1,CODE%
1280 CLOSE #1
1290 GOSUB 830
1300 LOCATE 10,5:COLOR 10:PRINT "Ok - (y/n)":LOCATE 10,16:INPUT X$:COLOR 14
1310 IF X$="n" THEN 1370
1320 IF X$="y" THEN 1760
1330 GOTO 1290
1340 GOSUB 830
1350 REM
1360 STOP
1370 REM @@@@@@@@  THIS SECTION DETERMINES TNT EQUIVALENCY FACTOR
@@@@@@@@@@
1380 REM          FOR TYPE OF CHARGE EXPLOSIVE USED IN PROBLEM
1390 REM @@@@@  PRINTING OUT EXPLOSIVE TYPE AND TNT EQUIVALENCY
FACTORS @@@@@
1400 CLS:LOCATE 1,30:PRINT "CANDIDATE TYPES OF EXPLOSIVE"
1410 LOCATE 2,20:PRINT "CODE% NUMBER, EXPLOSIVE TYPE & TNT EQUIVALENCY
FACTOR"
1420 CODE%=0
1430 FOR J=1 TO 41
1440 OPEN "R",#1,"CHGTYPE"
1450 FIELD#1,5 AS E$, 15 AS C$
1460 CODE%=CODE%+1
1470 GET #1,CODE%
1480 EF=CVS(E$):CT$=C$:IF CODE%>14 THEN 1510
1490 LOCATE CODE%+4,1:COLOR 14:PRINT CODE%;CT$;EF
1500 GOTO 1550
1510 IF CODE%>28 THEN 1540
1520 LOCATE CODE%-10,27:COLOR 15:PRINT CODE%;CT$;EF
1530 GOTO 1550
1540 LOCATE CODE%-23,53:COLOR 11:PRINT CODE%;CT$;EF
1550 CLOSE #1
1560 NEXT J
1570 LOCATE 22,10:COLOR 10:PRINT "TYPE CODE% FOR DESIRED CHARGE":COLOR 14
1580 INPUT CODE%:CLS
1590 REM @@@@@  PICKING OUT DESIRED EXPLOSIVE AND TNT EQUIVALENCY
FACTOR @@@@
1600 OPEN "R",#1,"CHGTYPE"
1610 FIELD#1,5 AS E$, 30 AS C$
1620 GET #1,CODE%
```

```
1630 EEE=CVS(E$):CCC$=C$
1640 CLOSE #1
1650 CODE%=1
1660 REM @@@@@  ADDING CHANGE TO CHARGE CHARACTERISTICS  @@@@@
1670 OPEN "R",#1,"CHARGE"
1680 FIELD#1,20 AS C$, 5 AS G$, 20 AS P$, 5 AS E$, 5 AS W$
1690 GET #1,CODE%
1700 CHG$=C$:GEO=CVS(G$):TYP$=P$:EF=CVS(E$):CW=CVS(W$)
1710 TYP$=CCC$:EF=EEE
1720 LSET C$=CHG$:LSET P$=TYP$
1730 LSET G$=MKS$(GEO):LSET E$=MKS$(EF):LSET W$=MKS$(CW)
1740 PUT #1, CODE%
1750 CLOSE #1
1760 GOSUB 830
1770 LOCATE 12,5:COLOR 10:PRINT "Ok - (y/n)":LOCATE 12,16:INPUT X$:COLOR 14
1780 IF X$="n" THEN 1810
1790 IF X$="y" THEN 1940
1800 GOTO 1760
1810 LOCATE 23,10:COLOR 10:PRINT "TYPE THE DESIRED CHARGE WEIGHT!"
1820 INPUT WWW:COLOR 14
1830 CODE%=1
1840 REM @@@@@  ADDING CHANGE TO CHARGE CHARACTERISTICS  @@@@@
1850 OPEN "R",#1,"CHARGE"
1860 FIELD#1,20 AS C$, 5 AS G$, 20 AS P$, 5 AS E$, 5 AS W$
1870 GET #1,CODE%
1880 CHG$=C$:GEO=CVS(G$):TYP$=P$:EF=CVS(E$):CW=CVS(W$)
1890 CW=WWW
1900 LSET C$=CHG$:LSET P$=TYP$
1910 LSET G$=MKS$(GEO):LSET E$=MKS$(EF):LSET W$=MKS$(CW)
1920 PUT #1, CODE%
1930 CLOSE #1
1940 REM
1950 RW=CW*EF:CGEO=GEO
1960 IF CGEO=1 THEN 1990
1970 IF CGEO=2 THEN 2000
1980 IF CGEO=3 THEN 2010
1990 REM THE HEMISPHERICAL CHARGE
1995 RW=(RW/1)^(1/3):GOTO 2030
2000 REM THE CYLINDRICAL CHARGE WITH L/D 3 TO 12
2005 RW=RW/1.27:RW=(RW/8)^(1/3):GOTO 2030
2010 REM THE SPHERICAL CHARGE
2015 RW=RW*1.8:REM FACTOR TO ACCOUNT FOR GROUND REFLECTION
2020 RW=(RW/1)^(1/3)
2025 GOTO 2030
2030 REM DETERMINATION OF IMPULSE WHICH MIGHT OVERTURN EQUIPMENT
```

```
2040 CLS:COLOR 14:LOCATE 8,25:PRINT "DETERMINATION OF MAXIMUM RANGE"
2050 LOCATE 9,36:PRINT "AT WHICH"
2060 LOCATE 10,31:PRINT "TARGET WILL OVERTURN"
2070 LOCATE 14,10:PRINT "TARGET =";T$
2080 LOCATE 15,10:PRINT "EXPLOSIVE TYPE =";TYP$
2090 LOCATE 16,10:PRINT "CHARGE WEIGHT =";CW
2100 LOCATE 24,1:COLOR 10,0,4:PRINT "CALCULATION IN PROGRESS!":COLOR 14,0,4
2110 RANGE=100*RW
2120 IF RANGE>100000! THEN DELTAR=100:GOTO 2210
2130 IF RANGE>10000 THEN DELTAR=50:GOTO 2210
2140 IF RANGE>500 THEN DELTAR=10:GOTO 2210
2150 IF RANGE>250 THEN DELTAR=5:GOTO 2210
2160 IF RANGE>100 THEN DELTAR=2:GOTO 2210
2170 IF RANGE>50 THEN DELTAR=1:GOTO 2210
2180 IF RANGE>25 THEN DELTAR=.75:GOTO 2210
2190 IF RANGE>15 THEN DELTAR=.5:GOTO 2210
2200 DELTAR=.01:GOTO 2210
2210 RANGE=RANGE-(DELTAR):LOCATE 21,60:COLOR 15:PRINT RANGE;DELTAR
2220 IF RANGE<2 THEN 2980
2230 IF CGEO = 1 THEN 2320
2240 IF CGEO = 2 THEN 2270
2250 IF CGEO = 3 THEN 2590
2260 REM  THE SCALED DOWN BLAST EXPRESSIONS FOR CYLINDER
2270 SD=RANGE/RW:LD=LOG(SD)
2280 LP=.363085*LD^2-4.530307*LD+13.04651
2290 FFP=EXP(LP)
2300 LI=.1410585*LD^2-1.863454*LD+.1301222
2310 FFI=EXP (LI)*RW:GOTO 2850
2320 SD=RANGE/RW
2330 REM @@@@@  FREE FIELD BLAST DATA FOR HEMISPHERE - SURFACE BURST
@@@@
2340 CODE%=1
2350 OPEN "R", #1, "CHGHEMIS"
2360 FIELD#1, 10 AS D$, 10 AS P$, 10 AS I$
2370 GET #1, CODE%
2380 D1=CVS(D$):P1=CVS(P$):I1=CVS(I$)
2390 CODE%=2
2400 GET #1,CODE%
2410 D2=CVS(D$):P2=CVS(P$):I2=CVS(I$)
2420 IF SD<D2 THEN 2470
2430 D1=D2:P1=P2:I1=I2
2440 CODE%=CODE%+1
2450 IF CODE%>46 THEN 2570
2460 GOTO 2400
2470 DELTAD=D2-D1:DEL=SD-D1:PERCENT=DEL/DELTAD
```

```
2480 IF P2>P1 THEN 2510
2490 FFP=P1-((P1-P2)*PERCENT)
2500 GOTO 2520
2510 FFP=P1+((P2-P1)*PERCENT)
2520 IF I2>I1 THEN 2550
2530 FFI=I1-((I1-I2)*PERCENT)
2540 GOTO 2560
2550 FFI=I1+((I2-I1)*PERCENT)
2560 FFI=FFI*RW
2570 CLOSE #1
2580 GOTO 2850
2590 SD=RANGE/RW
2600 REM @@@@@  FREE FIELD BLAST DATA FOR SPHERICAL - SURFACE BURST
@@@@
2610 CODE%=1
2620 OPEN "R", #1, "CHGSPHER"
2630 FIELD#1, 10 AS D$, 10 AS P$, 10 AS I$
2640 GET #1, CODE%
2650 D1=CVS(D$):P1=CVS(P$):I1=CVS(I$)
2660 CODE%=2
2670 GET #1,CODE%
2680 D2=CVS(D$):P2=CVS(P$):I2=CVS(I$)
2690 IF SD<D2 THEN 2740
2700 D1=D2:P1=P2:I1=I2
2710 CODE%=CODE%+1
2720 IF CODE%>48 THEN 2840
2730 GOTO 2670
2740 DELTAD=D2-D1:DEL=SD-D1:PERCENT=DEL/DELTAD
2750 IF P2>P1 THEN 2780
2760 FFP=P1-((P1-P2)*PERCENT)
2770 GOTO 2790
2780 FFP=P1+((P2-P1)*PERCENT)
2790 IF I2>I1 THEN 2820
2800 FFI=I1-((I1-I2)*PERCENT)
2810 GOTO 2830
2820 FFI=I1+((I2-I1)*PERCENT)
2830 FFI=FFI*RW
2840 CLOSE #1
2850 REM CALCULATION OF THE APPLIED IMPULSE AND COMPARISON
2860 SFFI=(ASV*ADC*FFI)/(AAP*HH):REM SCALED FREE FIELD IMPULSE
2870 SOOP=FFP/AAP:REM SCALED FREE FIELD OVERPRESSURE
2880 RRR=1.47*SOOP*SFFI
2890 SSS=7+SOOP
2900 TTT=(1+(3*SOOP/(7+SOOP)))*SOOP
2910 UUU=(1+.857*SOOP)^(1/2)
```

```
2920 STI=(RRR/SSS)+(TTT/UUU)
2930 SII=(STI*AAP*HH)/(ASV)
2940 IF SII<OASI THEN 2120
2950 CLS
2960 OPFFI=SFFP*FFI
2970 GOTO 3000
2980 LOCATE 23,40:PRINT "RANGE DECLINED < 2 FT, NO OVERTURN"
2990 END
3000 REM %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
3010 LOCATE 2: PRINT TAB(30) T$
3020 LOCATE 4:PRINT TAB(10) "Charge Geometry =";CHG$
3030 LOCATE 5:PRINT TAB(10) "Explosive Type =";TYP$
3040 LOCATE 6:PRINT TAB(10) "TNT Equivalency Factor =";EF
3050 LOCATE 8:PRINT TAB(10) "Overturn Threshold Impulse =";OASI;"psi-sec"
3060 LOCATE 9:PRINT TAB(10) "Impulse Applied to Target =";SII;"psi-sec"
3070 LOCATE 11:PRINT TAB(10) "Pressure =";FFP;"psi"
3080 LOCATE 12:PRINT TAB(10) "Impulse =";FFI;"psi-sec"
3090 LOCATE 13:PRINT TAB(10) "Range =";RANGE;"ft"
3100 LOCATE 15:PRINT TAB(30) "THE DATE OF RUN = ";DATE$
3110 COLOR 10:LOCATE 20,10:PRINT "Do you want to print results? (y or Enter)"
3120 INPUT NN$:COLOR 14:IF NN$="" THEN 3400
3130 IF NN$="y" THEN 3160
3140 GOTO 3110
3150 LPRINT"@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@"
3160 FOR J=1 TO 6:LPRINT:NEXT J
3170 LPRINT TAB(17) "PREDICTION OF RANGE FOR THRESHOLD OF OVERTURNING"
3180 LPRINT:LPRINT TAB(30) T$:LPRINT:LPRINT
3190 LPRINT TAB(30) "TARGET CHARACTERISTICS":LPRINT
3200 LPRINT TAB(10) "Air Drag Coefficient (ADC) =" TAB(50) ADC
3210 LPRINT TAB(10) "Total height of the target =" TAB(50) HH;"ft"
3220 LPRINT TAB(10) "Track width or depth of the base =" TAB(50) DEPTH;"ft"
3230 LPRINT TAB(10) "Height of the center of gravity =" TAB(50) HCG;"ft"
3240 LPRINT TAB(10) "Presented area =" TAB(50) AREA;"sq ft"
3250 LPRINT TAB(10) "Mass of the target =" TAB(50) M;"lbs"
3260 FOR J=1 TO 2:LPRINT:NEXT J
3270 LPRINT TAB(30) "CHARGE CHARACTERISTICS":LPRINT
3280 LPRINT TAB(10) "Charge Geometry =" TAB(50) CHG$
3290 LPRINT TAB(10) "Explosive Type =" TAB(50) TYP$
3300 LPRINT TAB(10) "TNT Equivalency Factor =" TAB(50) EF
3310 LPRINT TAB(10) "Charge Weight =" TAB(50) CW;"lbs":LPRINT:LPRINT
3320 LPRINT:LPRINT TAB(30) "CALCULATIONAL OUTPUT":LPRINT
3330 LPRINT TAB(10) "Impulse Threshold for Overturn =" TAB(50) OASI;"psi-sec"
3340 LPRINT TAB(10) "Impulse Applied to Target =" TAB(50) SII;"psi-sec":LPRINT
```

```
3350 LPRINT TAB(10) "Pressure =" TAB(50) FFP;"psi"
3360 LPRINT TAB(10) "Impulse =" TAB(50) FFI;"psi-sec":LPRINT
3370 LPRINT TAB(10) "RANGE TO OVERTURN THRESHOLD =" TAB(50)RANGE;"ft"
3380 LPRINT:LPRINT TAB(10) "THE DATE OF RUN = ";DATE$
3390 FOR J= 1 TO 25:LPRINT:NEXT J
3400 CLS:LOCATE 10,20:COLOR 10:PRINT "Do you wish to continue calculations?
3410 LOCATE 12,60:PRINT "y/Enter":INPUT X$:IF X$="" THEN 3440
3420 IF X$="y" THEN GOTO 60
3430 GOTO 3400
3440 CLS:LOCATE 12,30:COLOR 15:PRINT "THE END"
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In many survivability studies of blast effects on Army equipment, it is necessary to know the prospect for equipment being overturned. This report documents a small project in which an analytical procedure of W. E. Baker for predicting the overturn of targets by airblast has been incorporated in a personal computer (PC) program. The procedure, calculations of test cases used to verify accuracy, and a listing of the computer program are presented.

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